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(54) Circuit for operating a fluid-pressure driven piston

(57) The invention provides an operating device for a piston (11) running in a double-acting cylinder (10), whose piston rod (12) in the form of a tool or functional member is able to be brought into engagement with a workpiece (27) by being driven by pressure in chamber (14). Before the piston rod reaches the position of engagement on the work a position sensor (26) sends signal EO to electronic controller (24) which causes valve (23) to close so that chamber (15) must be drained through choke (21) which thus causes the piston to be retarded. A switch (28) detects the position of engagement by the change in pressure in at least one of the two cylinder chambers (13 and 14), and sends signal E1 which causes valve (23) to be opened again increasing the thrust on workpiece (27) so that welding etc can be performed.

After a preset time, controller (24) returns valves (20) and (23) to the position shown, whereupon the higher pressure produced by proportional regulating valve (19) over that of valve (18) causes the piston to be rapidly retracted to sensor (26) so that the whole cycle is repeated, up to a preset number of cycles.

In another embodiment, chamber (13) may be rapidly discharged through two chokes, or slowly through one. Further, controller (24) operates a fluid-pressure clamp, holding the rod for a predetermined time in the engagement position.

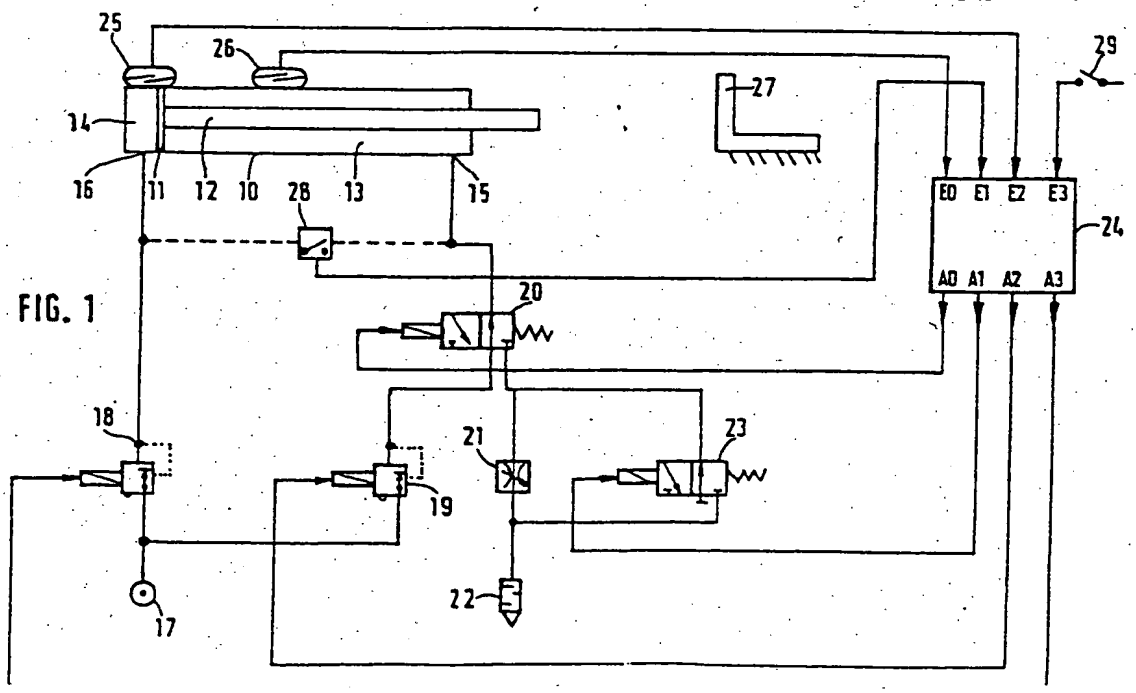

FIG. 1

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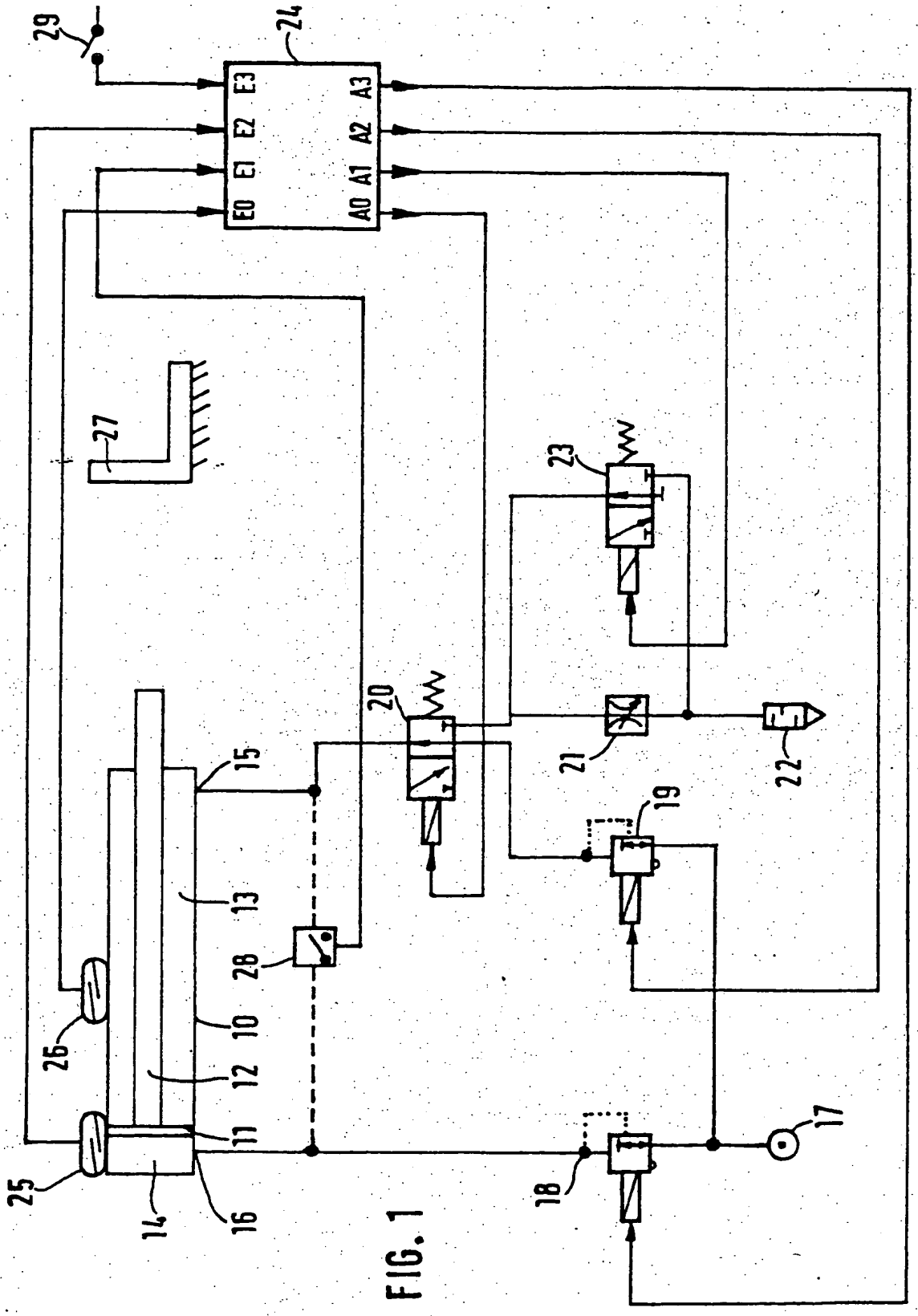

FIG. 1

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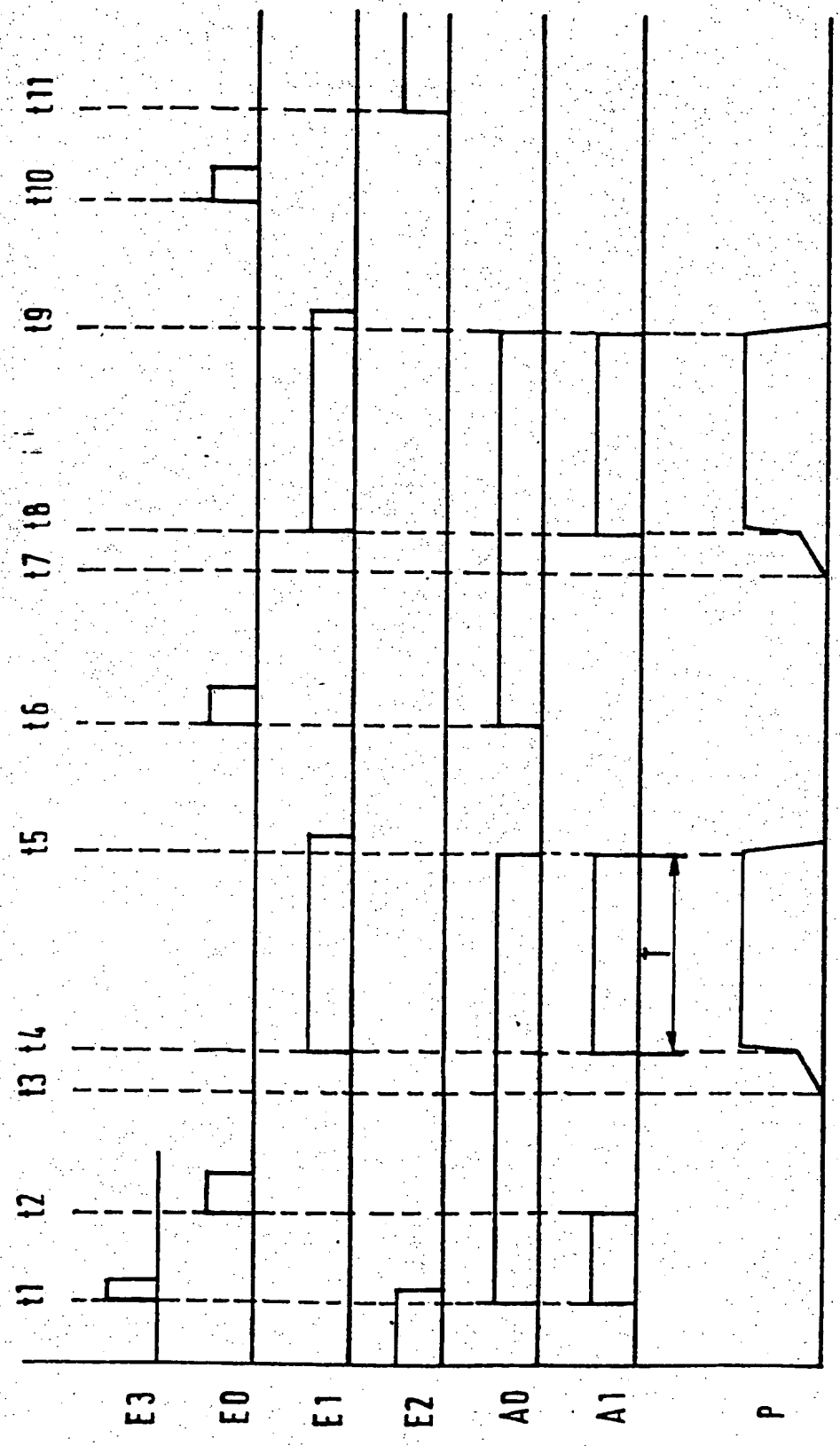

FIG. 2

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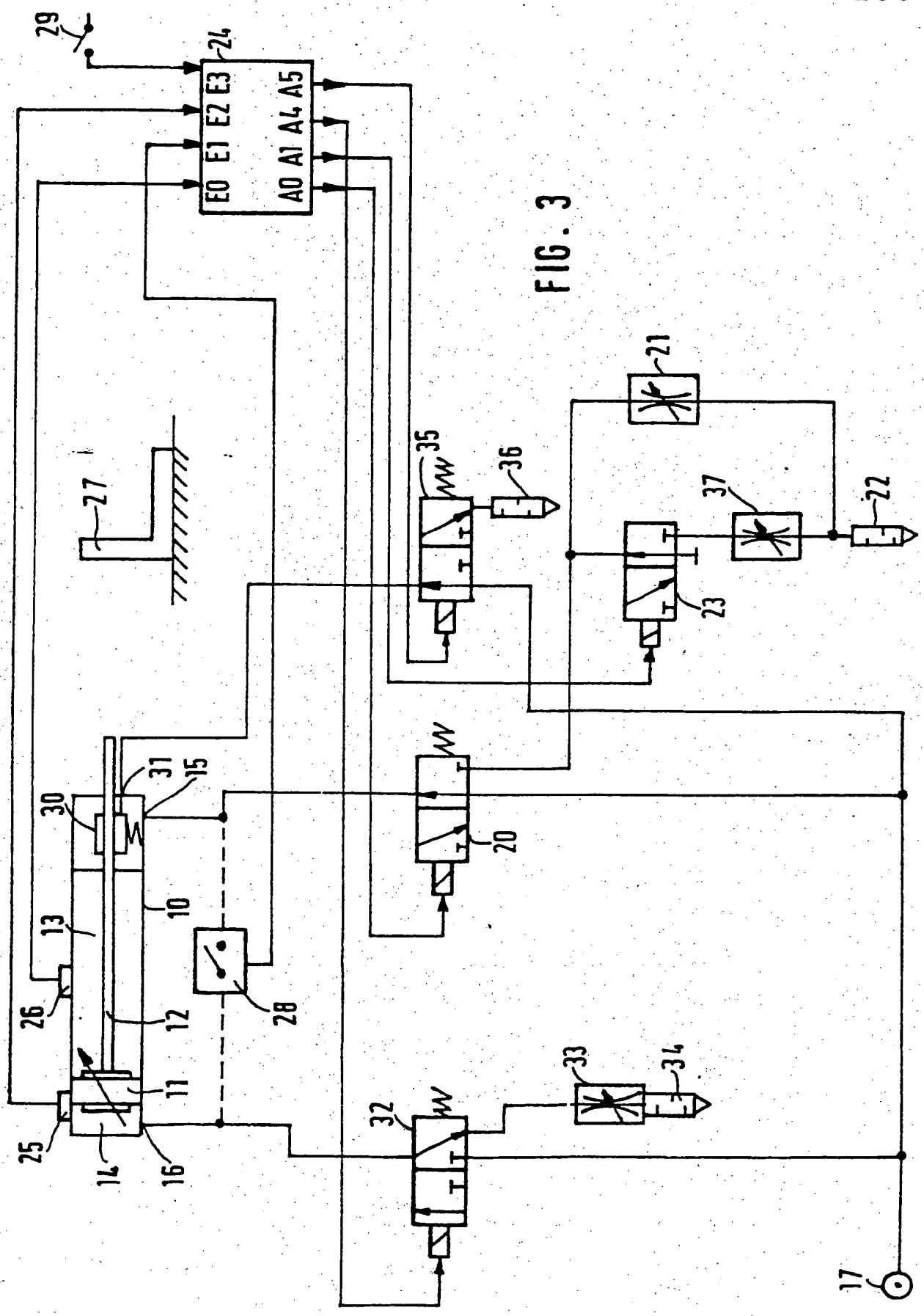

FIG. 3

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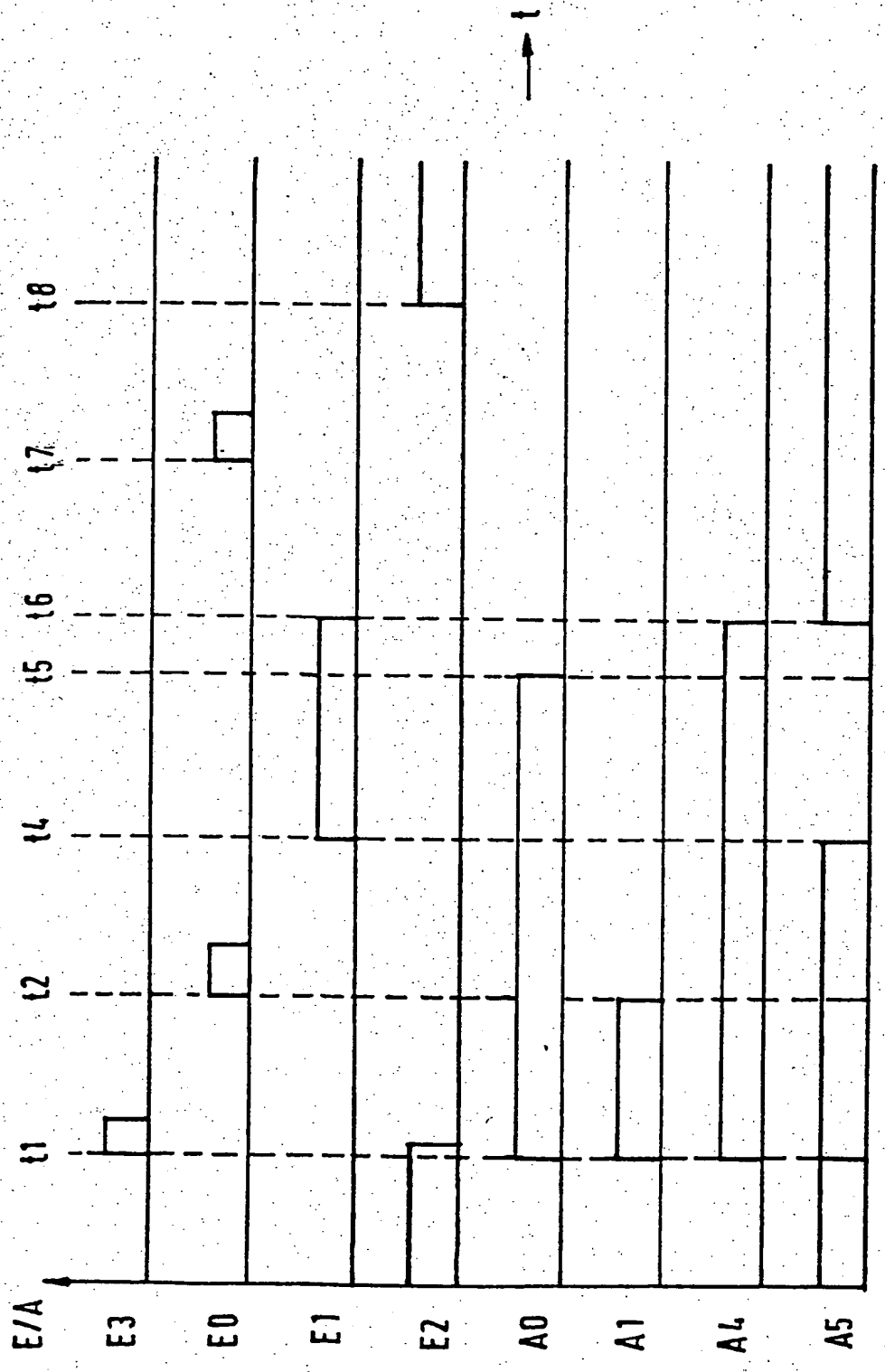

FIG. 4

--An operating Device for the Piston of a double acting Cylinder--

The present invention relates to an operating device for the piston of a double acting cylinder and more particularly but not exclusiely to such a device in which the piston rod in the form of a functional member is adapted to be brought into engagement with a workpiece.

Such operating devices are used for a large number of applications. To take an example the piston rod of such a cylinder may be constructed to act as the welding electrode of a welder. Or it is possible for it to drive such an electrode. In another application, the piston rod may be used as an adjustable abutment member for the manufacture of winding machines. Although in such a case it is often desirable for the piston rod to be moved very rapidly into the desired position, there is the further requirement for a gentle abutting action and then for a rapid retraction. In the case of welding for instance the welding electrode should come into gentle engagement in order to reduce flying sparks and consumption of the welding electrode, then however it should be subject to an increased thrust engagement force. Breaking away from the work after the welding operation should also

take place very abruptly. If such a piston rod is used an adjustable abutment, there is again a need for motion to take place rapidly into the desired position and for there to be gentle engagement, there being a provision for fixing the piston rod in the abutting setting in order to be able to withstand the high opposing forces. A further application for such operating or control devices is to be seen in steering the motion of a workhandling gripper and in the operation thereof.

Known operating devices and cylinder arrangements however do not sufficiently fulfill these requirements or they are technically overcomplex and overly high in price.

One object of the present invention resides in providing an operating device of the above-noted type which makes it possible for the piston rod of a double acting cylinder to be extended very rapidly into the neighborhood of the desired position where it comes into very gentle engagement with a workpiece despite the fact that the latter may not always be in exactly the same position so that some operation may then be carried out of the workpiece.

In order to achieve these or other objects in the invention an operating device for the piston of a dual chamber, double acting cylinder whose piston rod in the form of a functional member is adapted to be brought into engagement with a workpiece, is characterized in that the operating device comprises a position sensor for reducing the piston speed before the engagement of the piston rod takes place by changing the pressure ratio in the two cylinder chambers and furthermore a pressure-sensitive switch detecting the position of engagement by the change in pressure in at least one of the two cylinder chambers, such pressure-sensitive switch being functionally connected with a device which is adapted to carry out an operation in the engagement position.

Simply by the provision of a few standard components, that is to say a cylinder provided with position sensors, a pressure-sensitive switch and some control valves it is now possible to provide a low-cost and simply constructed operating device, which attains the above aims of the invention in a convincing manner. In this respect variations in

the speed of motion and of the individual settings are easily effected. There is more especially the advantage that variation in the position into which the piston rod is to be moved is possible within certain limits without any modification of the components or of the settings being needed. There is still the advantage of the rapid motion into the desired setting and a gentle engagement.

The claims define further developments and improvements in the operating device as defined.

A particularly simple way of ensuring the desired gentle abutment by reducing the piston velocity prior to engagement is one in which there is a first valve reducing the outlet flow cross section available for the fluid from the cylinder chamber on the piston rod side. This valve is preferably placed in one of two parallel outlet flow paths, the other one of which is provided with a preferably adjustable choke. As a result it possible for the reduction of the velocity and thus the gentleness of engagement to be adapted in a simple manner to suit needs.

If the thrust force of the piston rod on the work is to be increased in the position of engagement, as for example will be necessary if the piston rod is in the form of a welding electrode, this may be advantageously ensured by the first valve, which is in any case present and which is opened by a signal from the pressure-sensitive switch. The outlet flow resistance which is reduced as a result of this causes a greater thrust to be exerted on the workpiece.

If on the other hand the piston rod is to be designed in the form of a variable abutment, after gentle engagement a locking device fixing the position of engagement is put into operation, preferably by fluid power and via a second valve. Owing to the gentle engagement it is possible to move very precisely into the desired position of engagement and after locking very high bearing forces are possible. Despite the slow speed of engagement it is possible to move very smartly into this adjustable position.

In order to determine the dwell time in the position of engagement and/or the duration of the working operation in the engagement position it is more particularly suitable to use a timer

triggered by the signal from the pressure-sensitive switch. When its hold time has run to an end the latter may then cause reversal of the motion of the piston rod into the inward direction by actuating a third valve in the form of a two-way valve. This means that fully automated operations are possible.

For causing reversal the cylinder chamber on the piston rod side may be supplied with fluid through the third valve connecting it with a source of such fluid under a pressure whose pressure is higher than the pressure of the supply connected with the other cylinder chamber. By setting the pressures of the two sources of fluid, such sources preferably being in the form of pressure controllers able to be adjusted by an electronic controller, it is possible for the velocity of the inward motion and the force needed for disengagement from the work to be adapted to suit requirements.

It is however also possible to cause reversal by supplying the cylinder chamber on the piston rod side from a source of fluid under pressure via the third valve, a fourth valve connected with the other cylinder chamber causing a switch over from the pressure fluid supply to an outlet duct. The use of an adjustable choke on this outlet duct also provides a way of adjustably operating the inward motion.

The pressure-sensitive switch is preferably of the differential pressure type so as to respond to the pressure differential between the two cylinder chambers. As a result the switching over of the fourth valve serving for reversal may be triggered in a simple manner by means of a return signal from this pressure-sensitive switch.

In order to adjust the number of the automatically occurring strokes of the piston rod it is an advantage to provide an electronic operating device, a second reversal being respectively caused by a signal from the position sensor. Such multiple strokes are for instance necessary during a welding operation. These movements may take place in very rapid succession each time the welding electrode comes into engagement. The detachment force is in this case large every time it is required.

For operation of the valves in accordance with the sensor signals and the pressure-switch signals it preferred to provide a

freely programmed control system, more particularly in the form of a microcomputer. It may then simultaneously serve to set the hold time in the engagement position and for setting the number of automatically occurring reciprocations.

Two working examples of the invention will now be described with reference to the accompanying drawing in the ensuing account.

Figure 1 shows the circuit of a first working example of the invention which is suitable for performing welding operations.

Figure 2 is a diagram of the signals in order to explain the workings of the first example of the invention.

Figure 3 is a schematic of a second working example of the invention which may for instance be used as an adjustable abutment.

Figure 4 is a diagram of the signals produced in the second form of invention for purposes of explanation.

The first working example of the invention to be seen in figure 1 has a double-acting cylinder 10, a piston 11 and a piston rod 12 connected with same, the interior of the cylinder being divided up by the piston 11 into a cylinder chamber 13 on the piston rod side and a cylinder chamber 14 remote from the piston rod. The cylinder 10 is able to be operated by way of two connections 15 and 16 for a fluid leading to the cylinder chambers 13 and 14. The fluid is more especially a gas as in a pneumatic system or a liquid as in a hydraulic one.

A source 17 of fluid under pressure is connected via a proportional pressure regulating valve 18 with the connection 16 and via a further proportional pressure regulating valve 19 and a further, 3/2 way valve 20 placed in series thereto, with the connection 15. If

the valve 20 is operated, it will connect the connection 15 with a choke 21 in the form of a choke valve via which the fluid is able to be discharged through a muffler 22. The choke 21 is shunted by a valve 23, also in the form of a 3/2 way valve, when the latter is in the actuated condition.

The electronic operating device 24 has four control ports A0, A1, A2 and A3, via which the valves 20 and 23 and the proportional pressure regulating valves 19 and 18 may be operated. This electronic control device is preferably designed so that it may be freely programmed, and it is more especially in the form of a microcomputer.

Two position sensors 25 and 26 are mounted on the cylinder 10, the position sensor 25 producing a sensor signal in the retracted position of the piston 11, while the position sensor 26 is so arranged that it produces a sensor signal shortly prior to the time at which outwardly moving piston rod 12 engages a workpiece 27. The position sensors 25 and 26 are in the form of reed switches which react to the magnetic field of a magnet, not shown, or a magnetic ring secured to the piston 11. It is naturally possible for other types of position sensors to be used, as for example sensors to detect markings on the piston rod 12. These systems more especially include magnetic proximity switches. The sensor signals of the two position sensors 25 and 26 are supplied to the two control inputs E2 and E0 of the electronic operating device 24.

The fluid pressure at the connections 15 and 16 is applied to the differential pressure switch 28, which as from a given, preset pressure differential produces a control signal which is supplied to a further input E1 of the electronic operating device 24. Lastly, there is a starting switch 29 which is connected with a further control input E3 of this electronic operating device 24.

The manner of operation of the first working example of the invention to be seen in figure 1 will now be explained with reference to the signal diagram as shown in figure 2. In this diagram the signals supplied to the control inputs E0 - E3 and the control signals from the control outputs A0 - A3 are labeled accordingly. This working example of the invention is suitable for instance for use in electric

pot welding equipment, the piston rod 12 taking the form of the welding electrode or being used as a drive for such an electrode. Such an electrode has to be moved periodically very rapidly into engagement with the workpiece 27 to be welded, the work being moved past the electrode for producing a plurality of spot welds thereon. Although in this case the welding motion is to be performed very quickly, a gentle engagement at reduced speed is necessary in order reduce consumption of the electrode and the production of sparks. When the engagement position has been reached the electrode then has to be powerfully thrust onto the work and then after this the electrode has to be smartly disengaged from it.

The two proportional pressure regulating valves 18 are constantly actuated via the control outputs A2 and A3 during operation so that no corresponding control signals have been marked in the diagram. There is a higher pressure at the output of the proportional pressure regulating valve 19 than at the proportional pressure regulating valve 18 so that when such pressures act on the cylinder 10 the latter is held in the position indicated with the piston retracted. Via the control outputs A2 and A3 it is possible for the pressures as set by the proportional pressure regulating valves 18 and 19 to be modified and to be adapted to suit the respective conditions. More particularly, the pressure differential controls the speed of retraction of the piston 11 and pressure at the proportional pressure regulating valve 18 controls the speed of extension of the piston rod in cooperation with the choke 21 and the valve 23.

In response to a starting signal E3 produced by operation of the starting switch 29 at the time t1 control signals A0 and A1 are produced on the output side, such signals causing a switching over of the valves 20 and 23. Accordingly the cylinder chamber 14 receives the pressure of the proportional pressure regulating valve 18 while the fluid located in the cylinder chamber 13 is able to be drained off via the valve 20 and valve 23. This leads to a very smart outward motion of the piston rod 12.

When the piston 11 reaches the position of the position sensor 26, which corresponds to a position of the piston rod 12 just short of

the position of engagement on the work 27, the control signal A1 is terminated by the corresponding positions signal E0 so that the valve 23 closes. The fluid flowing from the cylinder chamber 13 now has to flow through the choke 21 so that owing to the increase in the resistance to discharge the speed of extension of the piston rod 12 is reduced. This reduction may be set as may be desired by varying the flow cross section of the choke 21.

At the point in time t3 the piston rod 12 will gently engage the workpiece 27 owing to its reduced speed. The pressure on the workpiece will increase until owing to the increase in the pressure differential in the cylinder chambers 13 and 14 the pressure differential switch 28 will produce an output signal E1 at the time t4. This produces a control signal A1 in the electronic operating device 24 and such signal causes the valve 23 to be opened again. This high-speed venting causes a rapid increase in the thrust of the piston rod 12 against the workpiece 27.

An internal timer within the electronic operating device 24 leads now to a hold time of T, while the piston rod is maintained in the pressed-condition, for instance in order to perform a welding operation. After this, at the time t5, the control signals A0 and A1 are turned off so that the two valves 20 and 23 are moved back into the positions as indicated. The higher pressure produced by the proportional pressure regulating valve 19 now acts in the cylinder chamber 13 so that the piston rod 12 is retracted at a high speed again until the piston reaches the position corresponding to the position sensor 26 at the time t6 and an input signal E0 is produced. This signal in turn produces a switching over of the valve 20 via a control signal A0 so that the direction of motion of the piston rod 12 is reversed again. The above-described operation will be repeated accordingly.

In the electronic operating device 24 it is possible to establish how many signals E0 are to effect a reversal of the direction of motion of the piston rod 12 in order to repeat, for instance, a welding operation or as from which signal E0 there is to be no further reversal of direction. This may be ensured by a simple

counting means. In the signal diagram as shown in figure 2 there is no reversal of the piston rod direction at the third signal E0 at the time t10, that is to say at the time t10 no signal A0 will be produced so that the piston rod 12 will moved back into the initial position as shown in which a signal E2 will be produced by the position sensor 25 and this will terminate the set of movements.

In the case of the second working example of the invention shown in figure 3 identical or similar components are provided with the same references and are not described again. The same applies for the inputs E and the outputs A of the electronic operating device 24. With the operating device in accordance with the second working example of the invention it is possible for adjustable abutments to be constructed, the piston rod 12 in this case taking the form of an abutment member. In this case as well there is firstly a rapid motion to a point just short of the abutment position and after this there is a gentle engagement on the latter with a reduced speed. The position of abutment is then locked and may serve as an opposing abutment for larger forces. Owing to the gentle abutment a preset position may be precisely moved into and sensed.

Amplifying the first embodiment of the invention the piston 11 is in this case provided with a terminal position damping device able to be adjusted on both sides. Furthermore, there is a locking device 30 for the piston rod 12, in the case of which in the non-actuated condition braking and frictional surfaces are thrust against the piston rod 12. By way of a connection 31 such locking may be overcome by fluid under pressure acting against the spring force.

Omitting the proportional pressure valves 18a and 19 in the present case the pressure fluid supply 17 is connected directly via the valve 20 with the cylinder chamber 13 and is connected with the cylinder chamber 14 via a valve 32, also in the form of a 3/2 way valve in its actuated condition. In the non-actuated condition of this valve 32 the cylinder chamber 14 is connected via a choke 33, designed in the form of an adjustable choke valve with a muffler 34 opening into a discharge pipe.

The pressurized fluid supply 17 is furthermore connected via a

further valve 35, having the form of a 3/2 way valve, with the connection 31, this valve 35 connecting when actuated the connection 31 with a muffler 36 opening into a discharge duct.

Lastly the valve 23 is connected in series with a further choke 37 in the form of an adjustable choke 37.

The manner of operation of the second working embodiment of the invention as shown in figure 3 will now be described with reference to the schematic shown in figure 4. A starting signal from the starting switch 29 causes operating signals A0, A1 and A4 to appear at the output of the electronic operating device 24 so that the valves 20, 23 and 32 are actuated with the result that the pressure fluid supply 17 is disconnected from the cylinder chamber 13 and coupled with the cylinder chamber 14, while the fluid in the cylinder chamber 13 is able to rapidly discharge via the parallel-connected chokes 21 and 37. The piston rod 12 is thus moved outwards at a high speed.

At the time t5 the piston will reach the position sensor 26 just before the piston rod 12 reaches its abutment position. In response to the signal E0 from the positional sensor 26 the control signal A1 for the valve 23 will be terminated. The valve closes so that the fluid leaving the cylinder chamber 13 will only be able to be discharged via the choke 21, the increase in the resistance to flow reducing the speed of the piston rod 12.

The engagement on the workpiece 27 takes place as was the case with the first working example of the invention, that is to say at the point in time t4 the differential pressure switch 28 will produce a signal E1, by which the control signal A5 for the valve 35 will be terminated. As result fluid may discharge from the licking device 30 so that the latter locks the piston rod 12 in the engagement setting.

After a fixed hold time as set in the electronic control device 24 the control signal A0 for the valve 20 is terminated at the time t5 so that the latter causes the cylinder chamber 13 to be reconnected with the supply 17 of fluid under pressure. This causes a build-up of pressure in the cylinder chamber 13 so that after a certain time the pressure differential switch 28 will open at the time t6. The end of the corresponding signal E1 causes the end of the control signal A4 and

the start of the control signal A5. As a result the fluid in the cylinder chamber 14 is able to discharge through the choke 13 and the locking device 30 is put out of action owing to the pressure acting on it. The piston rod 12 is accordingly very rapidly moved inwards in accordance with the setting of the choke 33.

When the piston 11 reaches the position of the position sensor 26 it possible for the correspondingly produced signal E0 to cause a reversal of the direction of motion of the piston rod, as was explained in connection with the first embodiment of the invention. In the case here illustrated however no reversal is desired so that the piston rod moves inwards again as far as its abutting position and when it reaches it at the time t8 a signal is produced by the position sensor 25, this preventing any further motion.

CLAIMS

1 An operating device for the piston of a dual chamber, double acting cylinder whose piston rod in the form of a functional member is adapted to be brought into engagement with a workpiece, said operating device comprising a position sensor for reducing the piston speed before the engagement of the piston rod takes place by changing the pressure ratio in the two cylinder chambers and furthermore a pressure-sensitive switch detecting the position of engagement by the change in pressure in at least one of the two cylinder chambers, such pressure-sensitive switch being functionally connected with a device which is adapted to carry out an operation in the engagement position.

2 The operating device as claimed in claim 1 wherein said position sensor is in the form of a magnetic sensor mounted on said cylinder and adapted to respond magnetically to said piston.

3 An operating device as claimed in claim 1 or claim 2 comprising a first valve adapted to reduce the cross section of a duct for fluid leaving the cylinder chamber adjacent to said piston rod and to reduce the speed of the piston.

4 An operating device as claimed in claim 3 comprising two parallel outlet ducts, and a choke in one such duct while the first valve is placed in the other such parallel duct.

5 An operating device as claimed in any one preceding claim wherein said device for performing an operation in the position of abutment is in the form of a device adapted to increase the thrust of the piston rod on the workpiece.

6 An operating device as claimed in claim 5 wherein the device increasing the thrust includes a first valve adapted to be opened in response to a signal from the pressure-sensitive switch.

7 An operating device as claimed in any one of the claims 1 through 4 wherein the device performing an operation in the position of abutment includes a locking device adapted to lock the piston rod in the engagement position.

8 An operating device as claimed in claim 7 comprising a second valve adapted to cause operation of said locking device by fluid power.

9 An operating device as claimed in claim 8 wherein said locking device includes at least one means with a braking and gripping surface and spring means for operation thereof, said fluid power being arranged to act against said spring means.

10 An operating device as claimed in any one preceding claim comprising a timer arranged to be triggered by a signal from the pressure-sensitive switch in order to determine the time in the engagement position.

11 An operating device as claimed in claim 10 comprising a third valve adapted to function as a two-way valve able to be switched over by the timer after the expiry of its hold time in order to cause motion of the piston rod in the inward direction.

12 An operating device as claimed in claim 11 wherein the third valve is arranged to be acted upon by fluid under pressure for switching over the cylinder chamber adjacent to the piston rod, the pressure of such fluid being higher than the pressure of a fluid supply connected with the other cylinder chamber.

13 An operating device as claimed in claim 12 comprising means for adjustment of the pressures of the two fluid supplies.

14 An operating device as claimed in claim 13 wherein said fluid supplies each include a pressure regulator able to be set by

means of an electronic controlling device.

15 An operating device as claimed in claim 11 wherein said third valve for switching over the cylinder chamber adjacent to the piston rod is connected with a supply of fluid under pressure for acting thereon, said operating device further comprising a fourth valve connected with the other cylinder chamber and serving for switching over from the supply of fluid under pressure to a discharge duct for reversing the direction of motion of the piston.

16 An operating device as claimed in any one of the preceding claims wherein the pressure-sensitive switch takes the form of a pressure differential switch responsive to the pressure differential between the two cylinder chambers.

17 An operating device as claimed in claim 15 and in claim 16 wherein the switching over to the fourth valve serving for reversal of motion is arranged to be triggered by a return signal of the pressure-sensitive switch.

18 An operating device as claimed in any one preceding claim comprising an electronic control device able to set a number of automatic reciprocations of the piston rod, a second reversal of motion being arranged to be triggered by a signal from the position sensor.

19 An operating device as claimed in any one preceding claim comprising a second position sensor adapted to respond to a withdrawn setting of the piston rod and to produce an output signal to cause the end of piston motion.

20 An operating device as claimed in any one preceding claim comprising a freely programmable control device for operation of the valves in response to the sensor signals and the pressure-sensitive switch signals.

21 An operating device as claimed in Claim 2 wherein said sensor is adapted to respond to a magnet connected with the piston, wherein said operating device includes a first valve for retarding said piston, said valve being placed in one of two parallel ducts, the other of said ducts having an adjustable choke placed therein, and said operating device further comprises a timer to determine the duration of an operation carried out by said piston rod, and furthermore a microcomputer as a freely programmable controlling device responding to the signals from the sensor and the pressure-sensitive switch.

22 An operating device substantially as described hereinbefore with reference to figures 1 and 2 of the accompanying drawings.

23 An operating device substantially as described hereinbefore with reference to figures 3 and 4 of the accompanying drawings.

24 Any novel subject matter or combination including novel subject matter herein disclosed in the foregoing Specification or Claims and/or shown in the drawings, whether or not within the scope of or relating to the same invention as any of the preceding Claims.

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